2016

GVU ANNUAL REPORT

Unlocking Human Potential Through Technical Innovation

Georgia Tech | **GVU Center**

Message from the Director

The GVU Center is an interdisciplinary research center on the Georgia Tech campus, focused on pushing the boundaries of how people interact with technology. From pioneering innovations in wearable computing, to innovative new approaches to STEAM education, to new applications of advanced AI technology, GVU researchers are empowering people through technical innovation. Throughout its nearly quarter-century history, the GVU Center has always brought together researchers from disciplines including computing, design, psychology, digital media, engineering, and more, who work closely with each other as well as with collaborators from industry and non-profits.

I hope the news highlights in this report give you a sense of the work going on in the GVU Center and the potential for impact it has on the world. If you're an alum or friend of GVU, I'd like to invite you to reconnect with us. If you're an external partner—or potential external partner—I invite you to contact me to learn more about the innovation going on at GVU and how we can work with you to provide cutting edge insight into real world problems.

Keith Edwards
Director, GVU Center

2016 FINANCIAL REPORT

1.9% 1.4%
1.1%
61.4% 34.2%
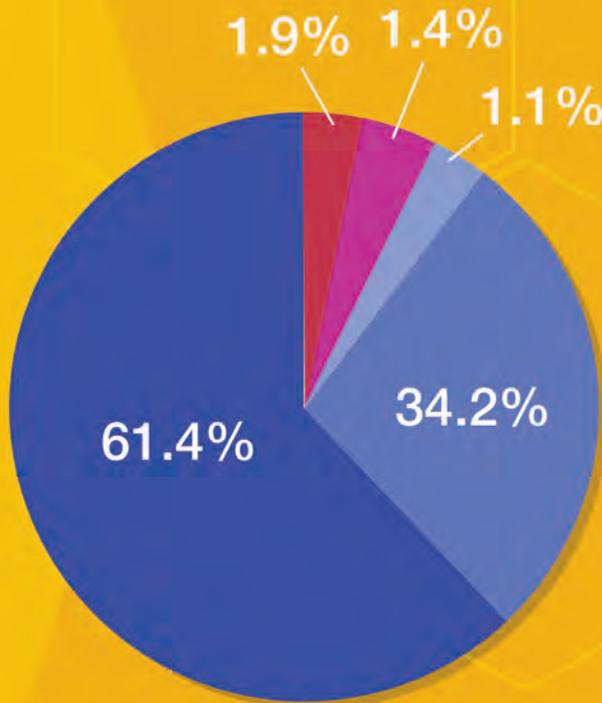
FY2016 EXPENDITURES

RESEARCH
- Federal Contracts $5,897,597
- Industry Partners $3,279,889
- State Funds $184,119

ADMINISTRATION
- Mixed $133,751

EXTERNAL RELATIONS
- Mixed $107,130

TOTAL $9,602,486

Corporate Partners

Humana. Texas Instruments TOYOTA Steelcase SAMSUNG QUALCOMM Panasonic P&G NOKIA MOTOROLA Microsoft Research

Willow Garage ETRI GE Google ACT JOHN DEERE Adobe Yahoo! zynga intel ESPN

About GVU Center

The GVU Center is dedicated to creating relevant computing solutions that address the needs of people. With more than 100 faculty from across Georgia Tech, our community's unique collaborative spirit fosters dynamic teams that are able to address complex human challenges. Explore an interactive look at our community online at *gvu.gatech.edu/explore* `Click Here`

Faculty chart (100+ Faculty)

- Enterprise Innovation Institute (1)
- Research Network Operations Center (1)
- Interactive Media Technology Center (5)
- College of Sciences — Psychology (8)
- College of Engineering
  - Electrical and Computer Engineering (4)
  - Biomedical Engineering (2)
  - Aerospace Engineering (1)
  - Civil and Environmental Engineering (1)
  - Mechanical Engineering (1)
- College of Design
  - Industrial Design (6)
  - Architecture (3)
  - Music (3)
- Ivan Allen College of Liberal Arts
  - Literature, Media, and Communication (15)
  - Public Policy (4)
  - International Affairs (2)
- Scheller College of Business — Business (1)
- College of Computing
  - Interactive Computing (39)
  - College-level (2)
  - Computational Science and Engineering (2)
  - Computer Science (2)

Research Areas chart (20+ Research Areas)

- Artificial Intelligence (2)
- Cognitive Science (2)
- Graphics & Animation (2)
- Music Technology (2)
- Robotics (2)
- Virtual Reality (1)
- Augmented Reality (3)
- Perception (3)
- Social Computing (3)
- Gaming (4)
- Online Communities (4)
- Collaborative Work (5)
- Health Informatics (5)
- Information Visualization (5)
- New Media (5)
- Civic Computing (7)
- Wearable Computing (7)
- Educational Technologies (8)
- Mobile & Ubiquitous Computing (10)
- Human-Computer Interaction (17)

Supporting Future Scholars Through the James D. Foley Endowment

A defining hallmark of research at the Georgia Institute of Technology is its interdisciplinary approach to creating the next innovations for society and breakthroughs in scientific and social challenges. The GVU Center fosters this ethos across all six Colleges at Georgia Tech by enabling people-centered computing research that pushes the boundaries of discovery.

At the 9th Annual GVU Graduate Awards Banquet in fall 2016, three Foley Scholars and the GVU Distinguished Master's Student were selected from 12 finalists representing Georgia Tech's top innovators in their respective fields.

Thanks to the generous support of donors to the James D. Foley GVU Center Endowment, the awards program has grown to include a new category for master's students that recognizes their distinct contributions to interactive technology. Each Foley Scholar receives $5,000 and the GVU Distinguished Master's Student is awarded $1,000.

We invite you to support and inspire the next generation of researchers in GVU through a gift to the James D. Foley GVU Center Endowment. Your support will contribute to the legacy of James D. Foley and future generations of scholars making notable contributions to creating technology for improving the human condition in critical areas across industry and society.

To make a gift, go to *gvu.gatech.edu/james-d-foley-gvu-center-endowment* `Click Here`

Clint Zeagler
*Foley Scholar 2016,
Wearable Computing*

Mariam Asad
*Foley Scholar 2016,
Civic Media*
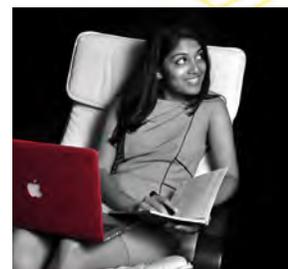
Samyukta Sherugar
*GVU Distinguished Master's Student 2016,
ICT4D*

Maia Jacobs
*Foley Scholar 2016,
Health Tracking*

2016 GVU Annual Report »

Computing technology research takes on many forms in the GVU Center. During Fiscal Year 2016 our researchers broke new ground on interactive technology. GVU fosters an ethos of discovery and innovation across all six Georgia Tech colleges by enabling people-centered computing research that pushes the boundaries of what is possible. This snapshot of our community shows computing possibilities becoming reality through the collaborative and dynamic environment at GVU.

Puppetry Arts Introduces Kids to Prototyping

Michael Nitsche (Digital Media) is leading a new NSF-funded project called Prototyping Puppets, which is designed to combine craft and performance art to teach early middle school students basic prototyping skills and introduce them to performance and basic hardware prototyping with the goal to attract students to STEM-related fields. Working with the Center for Puppetry Arts, researchers are conducting puppet-building workshops through 2018, and the project will serve as a way to engage student populations in physical computing through interest-driven exercises and support different creative practices in informal learning institutions, such as science museums and after-school centers.

A Future of Web Search Through Drawings, Not Words

Googling your doodles to return image results might soon be possible with **James Hays'** (Interactive Computing) work in building a database of 75,000 crowdsourced drawings that can retrieve similar photos from more than 125 categories. When text is a limiting factor in search, penciling a quick sketch and attaching it to a search query will result in more targeted results through the Sketchy Database. It allows for fine-grained associations between particular photos and sketches, and is being used in cross-domain networks to create the best sketch-photo pairs for future search capabilities.
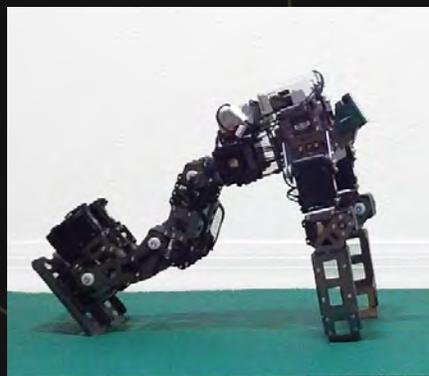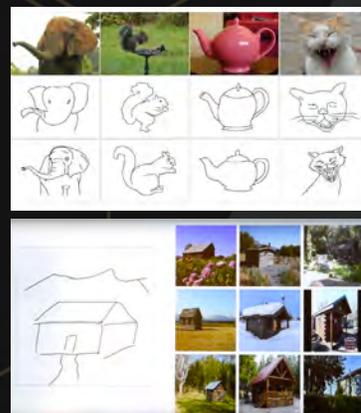

How to Fall Gracefully If You're a Robot
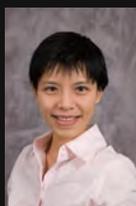
Ph.D. graduate Sehoon Ha and **Karen Liu** (Interactive Computing) have identified a way to teach robots how to fall without serious damage. The work is important as costly robots become more common in manufacturing and for health care or domestic tasks, such as working near the elderly. Their algorithm tells a robot how to react to a wide variety of falls – from a single step in order to recover from a gentle nudge, to a rolling motion that breaks a high-speed fall. Robots can minimize the damage or injury they might cause to themselves or others while falling by learning the best sequence of movements to slow their momentum.

Gender and Racial Disparities in Computer Science AP exam


Barbara Ericson (College of Computing) is leading efforts to bring attention to the number of females and minorities taking the Computer Science Advanced Placement Exam A across the country. Her research has revealed that in 2016 no African-Americans took the exam in nine states and fewer than 1 in 4 test takers was female (23 percent). The overall female pass rate was 61 percent, on par with 2015. The College Board introduced a new course in 2016 called AP CS Principles in an attempt to make computer science more accessible, and Ericson continues to run the Rise Up 4 CS program, in its fifth year and designed to improve AP CS pass rates for under-represented Georgia students.
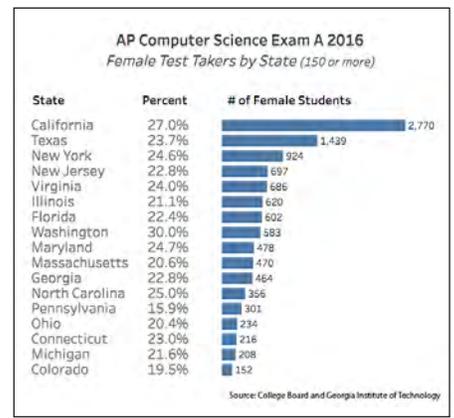
Computer Creates Games by Being a YouTube Couch Potato

Ph.D. CS candidate Matthew Guzdial and **Mark Riedl** (Interactive Computing) have developed an artificially intelligent system that views gameplay video from streaming services like YouTube or Twitch, analyzes the footage and then is able to create original new sections of a game. The team uses its AI system, the first of its kind, with well-known "2D platform" games (such as the original Super Mario Brothers) that will allow the AI level designer to replicate results across similar games. It focuses on the gaming terrain (not the playable character) and the positioning between elements on-screen. Guzdial has also developed an online editing tool with the AI system that lets it help people design their game levels.
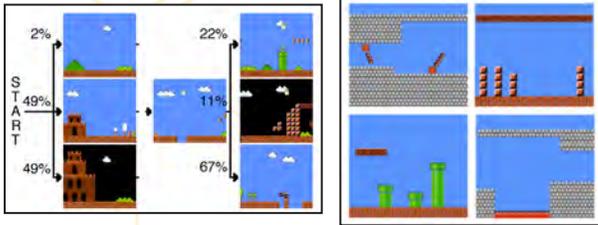
Wearable Robot Transforms Musicians into Three-Armed Drummers

Gil Weinberg (Music) led a research team in building a wearable robotic limb that allows drummers to play with three arms. The two-foot long "smart arm" can be attached to a musician's shoulder. It responds to human gestures and the music it hears. When the drummer moves to play the high hat cymbal, for example, the robotic arm maneuvers to play the ride cymbal. It knows what to play by listening to the music in the room and improvises based on the beat and rhythm. The smart arm is aware of where it's located at all times, where the instruments are, and the direction and proximity of the human arms, suggesting that in the future, similar arms could perform other jobs, such as assisting in surgery.

Left to right: Mike Winters, Roozbeh Khodambashi, Gil Weinberg, Tyler White (seated), Lea Ikkache, Hua Xiao and Mason Bretan

## Classifying Drivers with Behind the Wheel Behavior

Gregory Abowd (Interactive Computing) and Ph.D. CS student **Cheng Zhang** led efforts on a model capable of classifying drivers from their driving behaviors using low level sensors. Sensors included those available from the diagnostic outlet of cars and in smartphones. A six-person team developed the machine-learning model that could determine if a specific driver could be identified when a car was shared by more than one driver. The average classification accuracies attained with data collected from three different cars shared between couples in a naturalistic environment were 75.83% (phone sensors), 85.83% (car sensors) and 86.67% (both). One application of the work would be to initiate a hands-free mode for mobile devices when the car detects the person is the driver rather than passenger.

Curbing Harmful Behavior on Instagram Proves Difficult

A Georgia Tech study from **Munmun De Choudhury** (Interactive Computing) and Ph.D. HCC student **Stevie Chancellor** found that Instagram's decision to ban certain words commonly used by pro-eating disorder (pro-ED) communities has produced an unintended effect. The use of specific terms decreased when they were censored in 2012, but then users adapted by simply making up new, almost identical words, driving up participation within pro-ED groups by as much as 30 percent. The Georgia Tech researchers found that these communities are still very active and thriving despite Instagram's efforts to moderate discussion of the dangerous lifestyle.
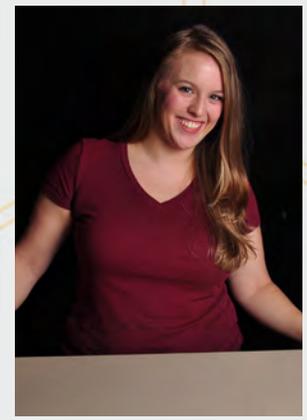
Vacation Highlights Effortlessly Edited with Computer Vision
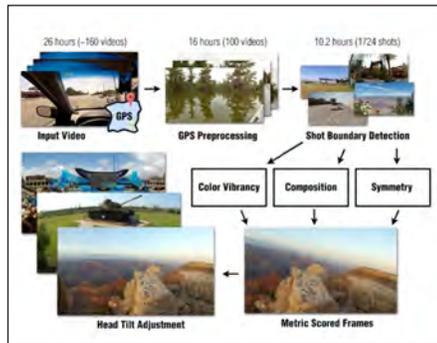
Researchers have developed a novel video-editing solution that automatically sorts and edits untouched footage into top highlights. The new approach is an algorithm – developed by students Daniel Castro and Vinay Bettadapura under the guidance of **Irfan Essa** (Interactive Computing) – that analyzes video for images with ideal artistic properties. It first considers geolocation, then composition, symmetry and color vibrancy to determine what is important or picturesque. The algorithm turned 26 hours of video into a 38-second highlight reel in a three-hour period. The team plans to generalize the approach, incorporate facial recognition, and develop data visualization techniques that make it easy to browse and search specific moments.

Understanding Internet Access in Developing Countries

Conducting interviews in Cuba, Ph.D. HCC student **Michaelanne Dye,** advised by **Neha Kumar** (International Affairs and Interactive Computing) and **Amy Bruckman** (Interactive Computing), found that access limitations and slow network speeds greatly restrict Cubans' Internet use. She is studying the implications, including how online activities are affected by social media use. To counter these web limitations, Cubans are collaborative, often conducting online research and posting photos for friends with less access. Dye has built a crowdsourced information retrieval system ("Cuba Intercambio") to help facilitate basic web access. It's an email-based service that allows web users outside the country to field questions and send information back to the requesters, giving Cubans a degree of more web access.

Left to right: Michaelanne Dye, Neha Kumar and Amy Bruckman

Robot is Trained on Variety of Domestic Tasks Through Crowdsourcing

Sonia Chernova (Interactive Computing) is designing robot interactions for the home that go far beyond vacuuming. Through crowdsourced data, her robot Nimbus is able to develop a model that discerns different objects from one another and can accomplish basic tasks just by observation, allowing non-expert users to work with the machine, no programming required. Nimbus's capabilities can span from the mundane – picking paper towels instead of tissues to clean up a mess – to vitally important, such as knowing not to pack nuts in a lunch if someone has a nut allergy. Nimbus is able to create many hypothetical scenarios for one task and substitute objects where necessary.

Autonomous Vehicles Maintain Control in Extreme Conditions

A robotics research team including **Jim Rehg** (Interactive Computing) has devised a novel way to help keep a driverless vehicle under control as it maneuvers at the edge of its handling limits. The approach could help make self-driving cars of the future safer under hazardous road conditions. The new technology was assessed by racing, sliding, and jumping one-fifth-scale, fully autonomous auto-rally cars at the equivalent of 90 mph. The technique uses advanced algorithms and onboard computing, in concert with installed sensing devices, to increase vehicular stability while maintaining performance.
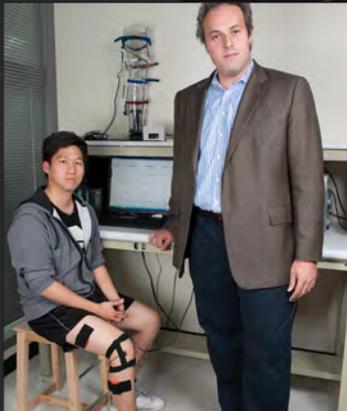
Hearing Snap, Crackle, Pop May Help Heal Your Knee

Omer Inan (Electrical and Computer Engineering) is developing a knee band with microphones and vibration sensors to listen to and measure the sounds inside the joint. It could lead to a future device to help orthopedic specialists assess damage after an injury and track the progress of recovery. Injured joints produce a more erratic sound while a healthy knee produces a more consistent pattern of noises. Also, the knee joint is surrounded by fluid, blunting sound waves that are exiting the joint for the skin. Inan's mission is to record sounds with consistent quality for medical use. The knee monitor takes advantage of micro-electromechanical systems microphones, or MEMS, also used in smartphones, to help solve for this challenge.

Two-Way Communication Between Dolphins and Humans

Thad Starner (Interactive Computing) and his students are creating a high-tech, dolphin- and human-friendly diver system that uses a wearable computing device to explore interspecies communication. Their team is developing pattern recognition software to help categorize and decode the dolphins' natural sounds as part of the Wild Dolphin Project, led by Denise Herzing. The wearable interface, called CHAT, is made up of an underwater speaker, two hydrophones, and a keypad that triggers output of a sound in the water to allow divers to send messages to the dolphins.

Providing Job Seekers More Informed Public Transit Options

Chris Le Dantec (Digital Media) led a team of student researchers in identifying metro Atlanta neighborhoods most in need of reliable public transit access to jobs. As part of Data Science for Social Good 2016, students developed a tool to assist Atlanta Regional Commission planners in visualizing access to employment based on income level from any point in metro Atlanta. The tool, Atlanta Access to Jobs map, displays accessible jobs from a given origin by walking or public transit with travel times approximate to a typical morning commute. Users can choose their place of origin, transit mode (walking or public transit), and maximum travel time. The job results are color coded based on level of pay.

The New Frontier of Artificial Intelligence Research

Artificial Intelligence is just beginning to permeate culture in meaningful ways — from virtual personal assistants to one Georgia Tech teaching AI — and growing interest in the research field will only accelerate its influence. Personal devices and networked systems will offer many entry points for AI. Financial markets, education systems, entertainment industries and governments are all employing the technology in some fashion right now. Georgia Tech researchers are inventing a future where we live side-by-side with intelligent machines by using diverse approaches for building and teaching artificially intelligent systems. This sample of work by faculty in the GVU Center at Georgia Tech shows the possibilities and visions that will shape the next generation of AI research.

AI Teaching Assistant Aims to Revolutionize Online Learning

Ashok Goel (Interactive Computing) and his students created Jill Watson, an artificially intelligent teaching assistant using IBM Watson's platform, to help answer the roughly 10,000 questions posted in forums from hundreds of students in a required course in Georgia Tech's Online Master of Science in Computer Science program. Many of the same questions are posed each semester by students, allowing Jill to use the data and eventually gain a 97 percent confidence level in fielding routine questions. The goal is to soon have the virtual teaching assistant answer 40 percent of all questions and help retain more students by providing better teaching support for online courses.

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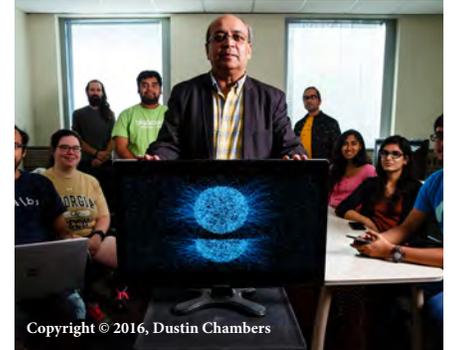
All the World's a Game, and AIs Will Provide Limitless Replay Value

Mark Riedl (Interactive Computing) is combining AI with the capabilities of mixed reality headsets, such as Microsoft's HoloLens, to put interactive content into physical environments. In his prototype game using an Oculus Rift (worn by Sasha Azad, MS CS 16), the game world itself is a living-room sized area, which Riedl's AI system uses to create procedurally generated content that is different every single time. For example, players control little avatars in the game to find the best path to jump from a coffee table to a couch, with the levels tailored for gameplay difficulty and to affect how the players move their physical bodies in the real world. Beyond entertainment, the research has applications for job training and education.
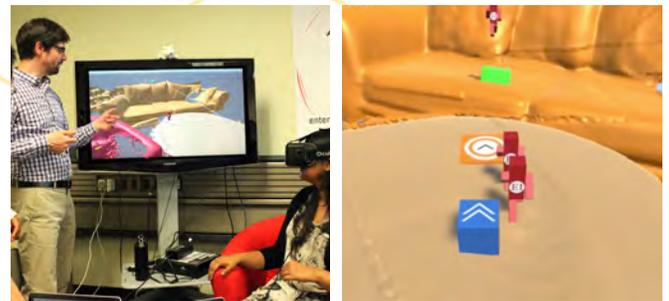
Virtual Dance Partner Shows the Possibilities of Creative Collaboration with AI

Ph.D. student **Mikhail Jacob** and **Brian Magerko** (Digital Media) co-lead the new LuminAI project, which allows people to create a collaborative performance with a computer-controlled dancer that "watches" the person and improvises its own moves based on prior experiences. When the human responds, the computerized figure or "virtual character" reacts, creating an impromptu dance couple. The LuminAI project is housed inside a 15-foot-tall geodesic dome, designed and constructed by Master's DM student Jessica Anderson, and lined with custom-made projection panels for dome projection mapping. A goal of the project is to have AI be creative with people to help them understand how they can co-exist with humans.